

# Manage Power Interruption Issues for Medical Equipment

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Designing equipment for medical applications is a well-understood discipline. Or is it? There is one area - concerning voltage dips and power interrupts - that warrants particularly close attention.

Most electronic design engineers working in the medical equipment sector will have a strong familiarity with the provisions of IEC 60601-1. The standard defines the general safety requirements for equipment that has 'not more than one connection to a particular supply mains and is intended to diagnose, treat, or monitor the patient under medical supervision and which makes physical or electrical contact with the patient'. IEC 60601-1 has been adopted by the UK and Europe as EN 60601-1, as well as most major industrialized countries, including the US (UL 60601-1), Canada (C22.2 No. 601.1), Japan (JIS T0601-1), Australia and New Zealand (AS/NZ 3200.1).

The 60601-1 safety standard applies to a diverse range of equipment intended for use in medical, dental and laboratory environments. Examples range from small items of equipment such as thermometers, infusion pump controls and endoscopic cameras, through to larger systems such as dialysis machines, MRI scanners and gamma imaging systems.

## Designing-in Power

Choosing or designing an AC-DC power supply for a medical product involves all the usual considerations, such as overall power budget, current and voltage requirements, conversion efficiency, physical size, control and monitoring functions, set-up or programmable features, and, of course, cost. On top of this comes the need to secure a power supply that has lower safety ground leakage and higher isolation than a standard non-medical unit, in order to comply with the 60601-1 safety standard.

Given that designing modern high-efficiency switch-mode power supplies is a craft in itself, and that medical equipment has to undergo strict compliance testing, most designers nowadays elect to use standard commercially available medical power supplies, or seek the help of a specialist power supply company to create a customized unit. Using power supplies that are already pre-approved to the 60601-1 safety standard helps medical equipment manufacturers speed compliance testing of their own products, and minimizes the risk of them encountering unexpected development problems outside their own area of expertise, which might negatively impact launch targets.

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Worldwide, there are a considerable number of medical power supply manufacturers to choose from, many of which produce excellent products. One of the leading companies is Emerson Network Power, which is responsible for the well-known Astec and Artesyn brands. Together, these two product brands encompass literally thousands of AC-DC power supplies and dc-dc converters, many of which are available in 60601-1 compliant versions. Emerson Network Power supplies medically approved standard and custom AC-DC power supplies covering a 40 to 4,860-Watt power band, to many of the world's most prestigious medical equipment manufacturers. The NLP250 Series is a typical example: these high power density open-frame 250-Watt AC-DC power supplies offer a choice of ten models, four of which are medically approved versions.

So, given this wide availability of 60601-1 compliant power supplies, surely it's simply a matter of choosing a product to suite the particular needs of the application, and then sitting back and basking in the glow of yet another design success? Well, not quite. IEC 60601-1 is a classic example of what is known as a base standard; it covers all the general requirements for electrical medical equipment, but it also has a number of associated standards, known as collateral standards. One of these is IEC 60601-1-2, which defines the rigorous electromagnetic compatibility (EMC) requirements of medical power supplies.

Obviously, all IEC 60601-1 compliant power supplies meet the EMC requirements of IEC 60601-1-2, otherwise they wouldn't be approved. And these requirements became a mandatory condition of sale back in 2004. But meeting the voltage dip requirements of IEC 60601-1-2 - which are themselves the subject of a further complementary pair of IEC standards known as 61000-4-11 and 61000-4-34 - is a matter of some controversy.

Both IEC 61000-4-11 and IEC 61000-4-34 define how equipment must be capable of tolerating voltage dips, voltage variations and short power interrupts on the ac mains supply. The standards specify the same depths and durations of voltage dips, and cover both single-phase and three-phase equipment. IEC 61000-4-11 applies to equipment rated at up to 16 A per phase connected to 50 Hz or 60 Hz ac supply networks, whereas IEC 61000-4-34 applies to equipment rated higher than 16 A per phase. For the purpose of discussion, we'll confine our attention to the lower power standard.

The problem is that deciding whether or not a piece of medical equipment meets the requirements of IEC 61000-4-11 is open to interpretation. Broadly speaking, the standard stipulates that the equipment should not suffer 'loss of functionality' for a 30 percent dip in supply voltage lasting 0.5 s, a 60 percent dip lasting 100 ms, and a 100% dip lasting 10 ms.

**Table: Evaluation of IEC 61000-4-11 Test Results**

Classification	Explanation
A	Normal performance within limits specified by the manufacturer, requestor or purchaser
B	Temporary loss of functionality or performance degradation which ceases after the disturbance ceases, and from which the equipment under test recovers its normal performance, without operator intervention
C	Temporary loss of functionality or performance degradation, the correction of which requires operator intervention
D	Irrecoverable loss of functionality or performance, owing to hardware or software damage, or loss of data

It should also not suffer ‘loss of functionality’ in the event of ac power being removed altogether for a period of 5 seconds. However, ‘loss of functionality’ is to some degree subjective, and the compliance test procedure recognizes this fact by defining four distinct classification levels, as shown in Table 1.

## Design Decisions

Provided that the equipment is not intended for critical life support functions, the choice of which classification category to adopt for compliance testing is left to the discretion of the equipment designer. It is also up to the designer to decide what constitutes full functionality – and therefore by definition, what also constitutes ‘loss of functionality’. This is inevitably something of a grey area. Most standard low to medium power open-frame medical power supplies, which represent by far the largest segment of the market, are too small and inexpensive to satisfy classification A – achieving lengthy hold-up times at full load with absolutely no degradation in voltage regulation demands the addition of significant holdup capacitance or larger input components for lower voltage operation. To help designers decide which classification to use for compliance testing their equipment, Emerson Network Power is in the process of adding detailed EMC characterization data to its Product Application Notes.

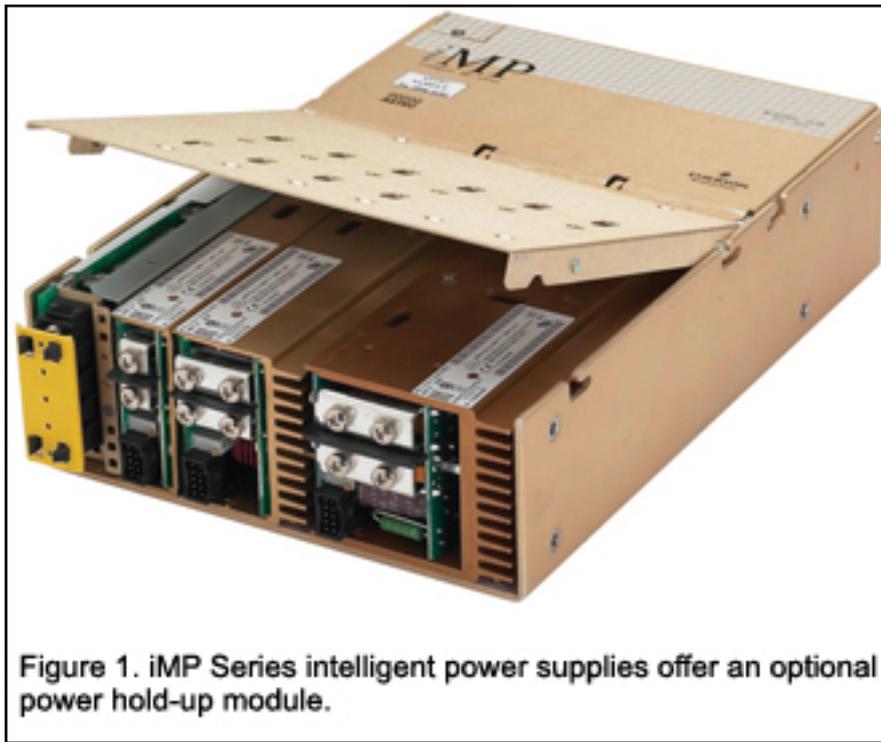


Figure 1. iMP Series intelligent power supplies offer an optional power hold-up module.

Medical equipment designers

seeking to satisfy the more stringent classification A can adopt a variety of techniques. They can oversize the power supply for the application, or fit more capacitance to the power supply output – which has maximum limits based on power supply design criteria. More expensive custom power supplies can also be considered if commercial justification exists. Another solution is to use a modular power supply, suitably equipped with extra capacitance to extend power hold-up. A prime example of this approach is provided by the medically approved versions of the iMP Series. These modular power supplies can be configured with a wide range of output modules to suit a variety of output voltage and output current requirements, and can deliver up to 1,500 Watts. They have an inherent power hold-up time of 20 ms minimum, at full load and independent of the applied AC supply voltage. This figure can be extended to 54 ms if required, simply by adding an optional power hold-up module.

Meeting the voltage dip requirements of IEC 60601-1-2 can prove expensive if the equipment designer over-specifies the power supply. A few minutes' thought about power budgets and equipment functionality will invariably prove to be time well spent.

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